PNE-229F

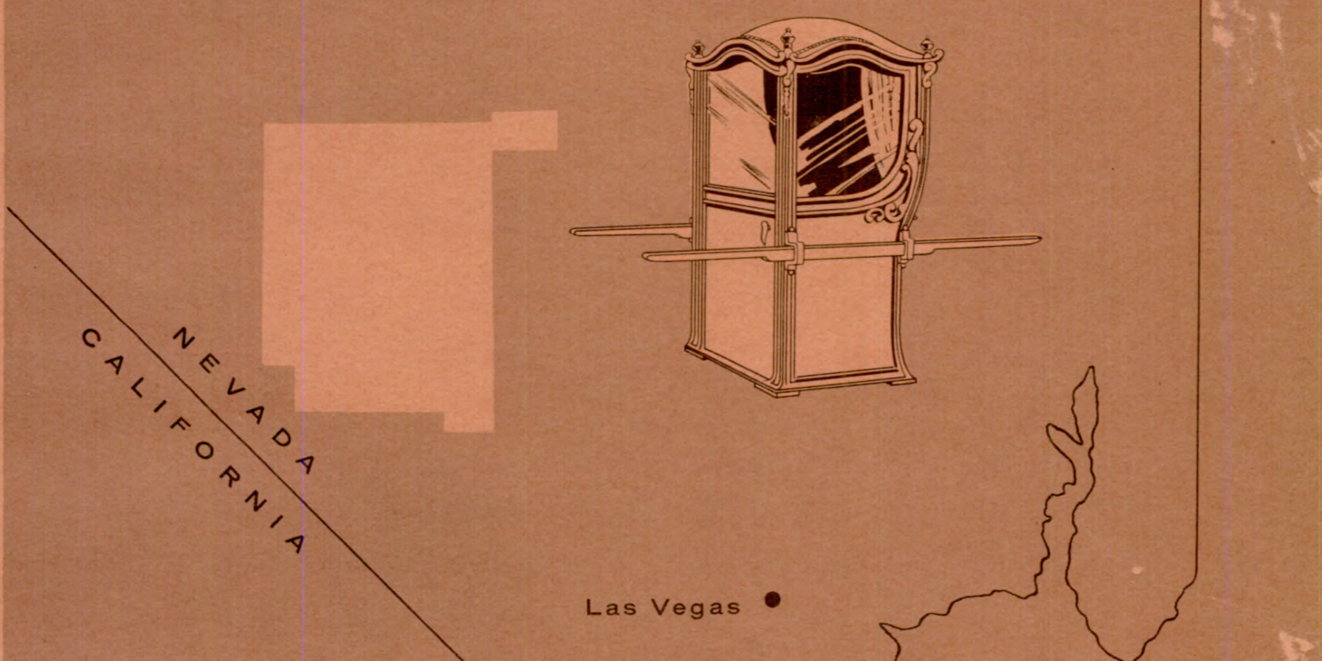
FINAL REPORT

Plowshare / peaceful uses for nuclear explosives

UNITED STATES ATOMIC ENERGY COMMISSION / PLOWSHARE PROGRAM

project SEDAN

NEVADA TEST SITE / JULY 6, 1962



Some Radiochemical and Physical Measurements of Debris from an Underground Nuclear Detonation

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ISSUED: JANUARY 7, 1964

PROJECT SEDAN

PNE 229F

SOME RADIOCHEMICAL AND PHYSICAL MEASUREMENTS OF DEBRIS FROM AN UNDERGROUND NUCLEAR DETONATION

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ABSTRACT

Fallout samples were collected from 2600 feet to 19,000 feet from ground zero in order to determine the mass per unit area, gamma activity per unit area, particle size distribution and specific activity versus particle size of the fallout; to determine the gamma decay rate and spectra of the samples; to perform leaching and exchange studies on the radioactive debris; to measure the release of gaseous fission product iodine; and to determine the radiochemical composition of the fallout particulate.

Twenty collectors (2 ft x 2 ft x 2 in. deep) were placed in the downwind sector at increasing distances. An iodine gas sampler was located approximately two miles downwind.

The fallout was well-distributed over the station array, and all collectors received significant deposits.

Analysis of the debris was performed at the Nevada Test Site.

Airborne iodine fission products were found in the contaminated field downwind from ground zero, and iodine fission products were found to volatilize or be otherwise released from particulate fallout.

Gamma decay measurements showed no evidence of radionuclide fractionation in debris from different locations, nor among different particle size fractions. Pulse height distributions also indicated no significant fractionation of gamma emitting radionuclides.

A 4-π ionization chamber decay rate measurement showed excellent agreement with a computed decay rate.

Measurements of mass and activity distributions indicate that the radionuclides are associated with the volume of the particle rather than with its surface area.

Radiochemical data are presented but extensive analysis was not attempted.

Sufficient data were obtained to meet all project objectives.

PREFACE

The author wishes to acknowledge the contribution made by Dr. Carl F. Miller, Assistant Director of Postattack Research, Office of Civil Defense, Department of Defense, in the initiation of the project, the design of the iodine experiment, and the execution of the field phase. Thanks are due to P. D. LaRiviere, Project Leader of Project 2.9 and 2.11 Small Boy, for making available the U. S. Naval Radiological Defense Laboratory (NRDL) analytical facilities at the Nevada Test Site, and for devising the iodine data treatment.

Credit for the radiochemistry must go to members of Project 2.10 Small Boy. Dr. E. C. Freiling, Project Leader, F. K. Kawahara, Assistant Project Leader, and L. R. Bunney, Deputy Project Leader of USNRDL distributed the samples, specified the radionuclides to be determined, and converted the raw data to comparable units (fissions).

TABLE 2.1 STATION LOCATION

Station No.	Distance From GZ	Bearing	Road
	ft	degrees	
1	2,700	N 45^{o}W	A
2	2,500	N 22.5^{o}W	A
3	2,560	0^{o}	A
4	2,800	N 22.5^{o}E	A
5	3,300	N 45^{o}E	A
6	5,200	N 45^{o}W	B
7	5,000	N 22.5^{o}W	B
8	5,100	0^{o}	B
9	5,400	N 22.5^{o}E	B
10	5,800	N 35.5^{o}E	B
11	9,300	N 9^{o}W	C
12	11,900	N 1.7^{o}E	G
13	14,200	N 13.5^{o}E	G-J
14	19,200	N 5^{o}E	D-J
15	17,000	N 7.5^{o}W	D
16	16,100	N 22.5^{o}W	D
17	16,500	N 13.5^{o}W	-
18	10,000	N 15^{o}E	F
19	9,800	N 30^{o}E	F
20	9,600	N 45^{o}E	F

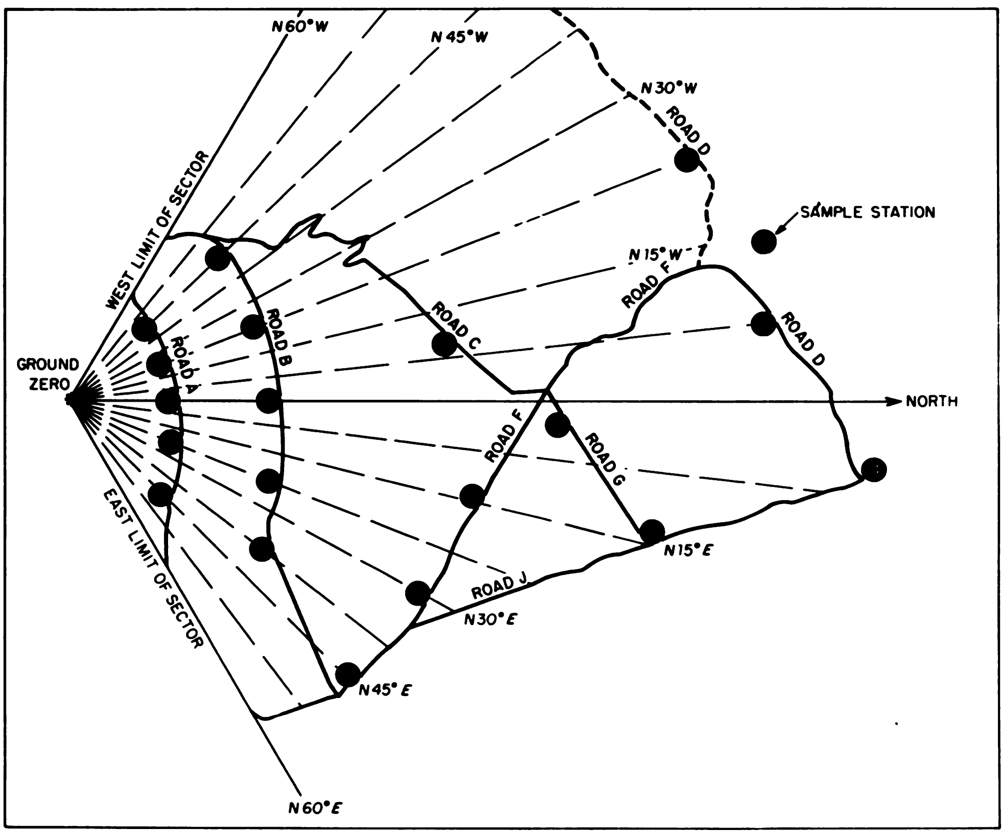

Figure 2.1 Sedan site showing sample stations.

detonation. The method is described in Reference 7.

Inspection of Table 3.10 indicates little difference in the results for equivalent fissions between Mo^{99} and Zr^{95}. The capture to fission ratio for W^{185} was higher for particles in the pan fraction than for large particles.

Certain discrepancies in the data are apparent such as the Sr^{89}/Sr^{90} ratio for 80 mesh particles from Station 10. Large differences are evident in the results for the pan fraction from Station 12 that are reported by the three contracting laboratories. Many of these discrepancies can no doubt be resolved by further analysis of the data.

While radiochemical fractionation was not observed by the gamma decay measurements nor by the pulse height spectra, perhaps the radiochemical data will provide a more sensitive test. R-values as discussed in Reference 8 are useful indices of fractionation. The R-value is defined as the ratio of the number of atoms of a radionuclide to the number of atoms of a reference radionuclide in a debris sample divided by the same ratio for thermal neutron fission of U^{235}. Enrichment or depletion are manifested by positive or negative deviations from the characteristic value.

TABLE 3.2 GAMMA ACTIVITY AND GROSS MASS OF DEBRIS COLLECTED

Sample Number	Activity at 100 hr	Empty Collector Activity at 100 hr	Weight Recovered	Activity Concentration	Mass Concentration	Specific Activity
	c/m	c/m	grams	c/m/sq ft	grams/sq ft	c/m/gram
6 SE	9565100.	51000.	4226.7	2391275.	1056.7	.2263
8 SE	6414972	30474.	3254.3	1603743.	813.6	.1973
9 SE	5191032	42868	2543.9	1297758.	636.0	.2040
10 SE	1646234.	11198.	1256.5	411559.	314.1	.1310
11 SE	1864910.	20491.	628.0	466228.	157.0	2969
12 SE	-	-	476.6	-	118.9	
13 SE	664817.	9305.	286.3	166204.	71.6	.2321
14 SE	-	-	44.8	-	11.2	
15 SE	346266.	0.	55.3	86567.	13.8	6272
16 SE	1356415.	26672.	229.0	339104.	57.2	5928
17 SE	633211.	0.	120.0	158303.	30.0	5276
18 SE	966452.	21611.	396.8	241636.	99.2	2435
19 SE	1487012.	4556.	495.0	371753.	123.8	3002
20 SE	755423.	4057.	363.2	188856.	90.8	2079

TABLE 3.5 GASEOUS IODINE MEASURED FROM SHOT TIME UNTIL D+1

	Debris in Samples	0.53 Mev Photons/sec at Zero Time in AgI Precipitate Measured on 8 July at 2100 hr
	grams	
Covered sample	0.1	95
Uncovered sample	95.8	283

TABLE 3.6 LOSS OF IODINE FROM PARTICULATE DEBRIS BY AIR EXPOSURE

Sample	Duration of Air Exposure	4-pi Activity at 11 Days Total	4-pi Activity at 11 Days Iodine	Observed Iodine/Total	Observed I x 100 / Expected I*
		ma	ma		
1	1	180×10^{-9}	-		
2	2	185×10^{-9}	-		
3	3	195×10^{-9}	15.6×10^{-9}	0.0800	33.3
4	4	170×10^{-9}	13.0×10^{-9}	0.0764	30.5
5	5	170×10^{-9}	13.2×10^{-9}	0.0776	31.1
6	6	165×10^{-9}	11.5×10^{-9}	0.0697	27.9
7	7	165×10^{-9}	10.5×10^{-9}	0.0636	25.4
8	8	160×10^{-9}	8.0×10^{-9}	0.0500	20.0
9	9	160×10^{-9}	6.4×10^{-9}	0.0900	16.0
10	10	165×10^{-9}	-		

*Reference 5 at 11 days $\frac{I(ma)}{\text{Fission Product }(ma)} = 0.25$ expected

TABLE 3.7 THREE DAY LEACHING

Sample	Measured on 9 July 1962		% Leached
	Total Sample	25 ml Solution	
	ma x 10^{11}	ma x 10^{11}	
pH 1.0			
42 mesh	7,360	340	4.61
150 "	6,010	440	7.32
325 "	8,048	678	8.42
Pan "	15,190	2,420	15.93
pH 4.0			
42 mesh	27,120	390	1.44
150 "	5,562	502	9.02
325 "	8,420	1,060	12.58
Pan "	16,820	2,860	17.0
pH 6.0			
42 mesh	24,064	302	1.25
150 "	5,509	547	9.93
325 "	7,604	942	12.39
Pan "	15,800	2,542	16.3
pH 10.0			
42 mesh	8,040	230	2.86
150 "	4,640	350	7.54
325 "	7,170	730	10.2
Pan "	14,950	990	6.62

TABLE 3.8 EIGHT DAY LEACHING

Sample	Measured on 14 July 1962 Total Sample	25 ml Solution	% Leached
	ma x 10^{11}	ma x 10^{11}	
pH 1.0			
42 mesh	4195	135	3.22
150 mesh	1855	195	10.51
325 mesh	1335	125	9.36
Pan mesh	3670	410	11.2
pH 4.0			
42 mesh	2805	45	1.60
150 mesh	1330	70	5.26
325 mesh	1820	110	6.04
Pan mesh	3625	365	10.07
pH 6.0			
42 mesh	4130	70	1.64
150 mesh	1320	60	4.54
325 mesh	1865	125	6.70
Pan mesh	3660	350	9.56
pH 10.0			
42 mesh	1920	40	2.08
150 mesh	1530	70	4.58
325 mesh	1895	135	7.12
Pan mesh	3630	350	9.64

TABLE 3.9 THREE DAY EXCHANGE

	Measured on 9 July 1962 Total Sample	Adobe	% Exchange
	ma x 10^{11}	ma x 10^{11}	
Adobe	Total	Adobe	
42 mesh	4570	215	4.70
150 mesh	3380	430	12.72
325 mesh	5900	3050	51.69
Clay	Total	Clay	
42 mesh	5800	300	5.17
150 mesh	3300	950	28.79
325 mesh	5800	4120	71.03

TABLE 3.10 NRDL SEDAN RADIOCHEMICAL RESULTS

Units: Equivalent Fissions/Gm

Station No.	Screen Retained On	Isotope	Value	Standard Deviation
	Tyler Mesh			%
10	7, 12, 24	Sr^{89}	2.25×10^{11}	
		Sr^{90}	4.15×10^{11}	
		Y^{91}	6.52×10^{11}	
		Zr^{95}	3.89×10^{11}	
10	80	Sr^{89}	1.29×10^{10}	
		Sr^{90}	1.35×10^{12}	
		Y^{91}	2.31×10^{11}	
		Zr^{95}	3.19×10^{11}	
10	170	Sr^{89}	5.26×10^{11}	
		Sr^{90}	8.88×10^{11}	
		Y^{91}	6.72×10^{11}	
		Zr^{95}	7.00×10^{11}	
10	325	Sr^{89}	1.05×10^{12}	
		Sr^{90}	1.64×10^{12}	
		Y^{91}	9.21×10^{11}	
		Zr^{95}	5.49×10^{11}	
10	Pan	Sr^{89}	2.27×10^{11}	
		Sr^{90}	4.25×10^{11}	
		Y^{91}	3.70×10^{11}	
		Zr^{95}	4.99×10^{11}	
12	7, 12, 24	Sr^{89}	4.51×10^{11}	
		Sr^{90}	$< 4.83 \times 10^{12}$	
		Y^{91}	1.19×10^{12}	
		Zr^{95}	1.41×10^{12}	

(Continued)

TABLE 3.10 (CONTINUED) NRDL SEDAN RADIOCHEMICAL RESULTS

Units: Equivalent Fissions/Gm

Station No.	Screen Retained On	Isotope	Value	Standard Deviation
	Tyler Mesh			%
12	80	Sr^{89}	1.90×10^{11}	± 3.7
		Sr^{90}	3.32×10^{11}	± 3.0
		Y^{91}	7.27×10^{11}	± 2.3
		Zr^{95}	4.95×10^{11}	
		Mo^{99}	5.06×10^{11}	
		Ru^{103}	-	
		Ru^{106}	-	
		I^{131}	3.97×10^{11}	± 5.5
		Te^{131}	-	
		Te^{132}	2.08×10^{11}	± 7.2
		Cs^{136}	$< 4.88 \times 10^{11}$	
		Cs^{137}	2.02×10^{11}	± 11.0
		Ba^{140}	4.24×10^{11}	
		Ce^{141}	1.50×10^{12}	
		Ce^{144}	1.37×10^{12}	
		W^{185}	1.44×10^{12}*	± 3.4
12	170	Sr^{89}	4.23×10^{11}	
		Sr^{90}	5.60×10^{11}	
		Y^{91}	4.00×10^{11}	
		Zr^{95}	5.70×10^{11}	
12	325	Sr^{89}	1.15×10^{12}	
		Sr^{90}	1.64×10^{11}	
		Y^{91}	5.68×10^{11}	
		Zr^{95}	5.16×10^{11}	
12	Pan	Sr^{89}	6.34×10^{11}	
			1.92×10^{12}	
			1.08×10^{12}	
		Sr^{90}	5.17×10^{11}	
			1.93×10^{11}	
			1.48×10^{12}	± 5.0

*Units = Atoms

(Continued)

TABLE 3.10 (CONTINUED) NRDL SEDAN RADIOCHEMICAL RESULTS

Units: Equivalent Fissions/Gm

Station No.	Screen Retained On	Isotope	Value	Standard Deviation
	Tyler Mesh			%
12	Pan	Y^{91}	6.20×10^{11}	
			7.77×10^{11}	
			9.20×10^{11}	
		Zr^{95}	7.29×10^{11}	
			2.81×10^{11}	
			1.94×10^{11}	
12	Pan	Mo^{99}	1.55×10^{11}	
			-	
			2.43×10^{11}	± 2.9
		Ru^{103}	3.84×10^{11}	
			-	
			-	
12	Pan	Ru^{106}	5.55×10^{11}	
			-	
			-	
		I^{131}	-	
			-	
			5.85×10^{11}	± 4.1
12	Pan	Te^{131}	-	
			-	
			-	
		Te^{132}	4.51×10^{11}	
			-	
			7.42×10^{10}	± 7.3
12	Pan	Cs^{136}	1.50×10^{11}	
			-	
			5.25×10^{11}	
		Cs^{137}	5.99×10^{11}	
			-	
			9.99×10^{11}	± 2.2

(Continued)

TABLE 3.10 (CONTINUED) NRDL SEDAN RADIOCHEMICAL RESULTS

Units: Equivalent Fissions/Gm

Station No.	Screen Retained On	Isotope	Value	Standard Deviation
	Tyler Mesh			%
12	Pan	Ba^{140}	$5.78x10^{11}$	
			-	
		Ce^{141}	$7.75x10^{11}$	
			$9.06x10^{11}$	
			-	
			$2.96x10^{11}$	± 14.3
12	Pan	Ce^{144}	$2.43x10^{11}$	
			-	
		W^{185}	$2.32x10^{11}$	± 2.7
			- *	
			- *	
			$2.19x10^{12}$*	± 12.0
13	7	Sr^{89}	$6.29x10^{11}$	
		Sr^{90}	$9.85x10^{11}$	
		Y^{91}	$2.07x10^{12}$	
		Zr^{95}	$4.47x10^{12}$	
13	12	Sr^{89}	$1.85x10^{11}$	
		Sr^{90}	$3.48x10^{12}$	
		Y^{91}	$5.88x10^{11}$	
		Zr^{95}	$4.32x10^{11}$	
13	24	Sr^{89}	$4.45x10^{11}$	
		Sr^{90}	$6.23x10^{11}$	
		Y^{91}	$8.81x10^{11}$	
		Zr^{95}	$4.99x10^{12}$	
13	80	Sr^{89}	$4.19x10^{11}$	
		Sr^{90}	$6.37x10^{11}$	
		Y^{91}	$1.39x10^{12}$	
		Zr^{95}	$1.94x10^{11}$	

*Units = Atoms

(Continued)

TABLE 3.10 (CONTINUED) NRDL SEDAN RADIOCHEMICAL RESULTS

Units: Equivalent Fissions/Gm

Station No.	Screen Retained On	Isotope	Value	Standard Deviation
	Tyler Mesh			%
13	170	Sr^{89}	$5.05 x 10^{11}$	
		Sr^{90}	$4.83 x 10^{11}$	
		Y^{91}	$3.93 x 10^{11}$	
		Zr^{95}	$4.87 x 10^{11}$	
13	325	Sr^{89}	$1.22 x 10^{12}$	
		Sr^{90}	$9.66 x 10^{11}$	
		Y^{91}	$6.22 x 10^{11}$	
		Zr^{95}	$5.46 x 10^{11}$	
13	Pan	Sr^{89}	$2.60 x 10^{12}$	
		Sr^{90}	$2.32 x 10^{12}$	
		Y^{91}	$7.82 x 10^{11}$	
		Zr^{95}	$3.16 x 10^{11}$	
14	7, 12	Sr^{89}	$2.60 x 10^{11}$	
		Sr^{90}	$5.21 x 10^{11}$	
		Y^{91}	$7.47 x 10^{11}$	
		Zr^{95}	$1.11 x 10^{12}$	
14	24	Sr^{89}	$2.11 x 10^{11}$	
		Sr^{90}	$4.02 x 10^{11}$	$\pm$ 3.3
		Y^{91}	$1.53 x 10^{12}$	$\pm$ 4.0
		Zr^{95}	$1.06 x 10^{12}$	
		Mo^{99}	$1.17 x 10^{12}$	
		Ru^{103}	-	
		Ru^{106}	$2.13 x 10^{11}$	$\pm$ 7.3
		I^{131}	$4.88 x 10^{11}$	$\pm$ 8.3
		Te^{131}	-	
		Te^{132}	$3.51 x 10^{11}$	$\pm$ 9.5
		Cs^{136}	$1.07 x 10^{12}$	$\pm$ 7.1
		Cs^{137}	$2.57 x 10^{11}$	$\pm$ 3.7
		Ba^{140}	$7.59 x 10^{11}$	$\pm$ 4.3
		Ce^{141}	$< 8.63 x 10^{11}$	
		Ce^{144}	$1.24 x 10^{12}$	
		W^{185}	$3.28 x 10^{12}$*	$\pm$ 4.6

*Units = Atoms

(Continued)

TABLE 3.10 (CONTINUED) NRDL SEDAN RADIOCHEMICAL RESULTS

Units: Equivalent Fission/Gm

Station No.	Screen Retained On	Isotope	Value	Standard Deviation
	Tyler Mesh			%
14	80	Sr^{89}	$2.61x10^{11}$	
		Sr^{90}	$4.66x10^{11}$	± 2.5
		Y^{91}	$1.78x10^{12}$	± 2.5
		Zr^{95}	$1.24x10^{12}$	± 6.5
		Mo^{99}	$1.27x10^{12}$	
		Ru^{103}	-	
		Ru^{106}	-	
		I^{131}	$1.70x10^{11}$	± 16.0
		Te^{131}	-	
		Te^{132}	$3.91x10^{11}$	± 5.1
		Cs^{136}	$1.19x10^{12}$	± 19.0
		Cs^{137}	$3.42x10^{11}$	
		Ba^{140}	$8.92x10^{11}$	
		Ce^{141}	$1.10x10^{12}$	± 10.7
		Ce^{144}	$1.44x10^{12}$	
		W^{185}	$3.62x10^{12}$*	
14	170	Sr^{89}	$5.63x10^{11}$	
		Sr^{90}	$9.75x10^{11}$	
		Y^{91}	$1.04x10^{12}$	
		Zr^{95}	$1.65x10^{12}$	
14	325	Sr^{89}	$8.27x10^{11}$	
		Sr^{90}	$9.37x10^{11}$	
		Y^{91}	$9.06x10^{11}$	
		Zr^{95}	$8.43x10^{11}$	
14	Pan	Sr^{89}	$1.17x10^{12}$	± 2.6
		Sr^{90}	$1.35x10^{12}$	± 7.3
		Y^{91}	$1.17x10^{12}$	
		Zr^{95}	$3.19x10^{11}$	± 9.8
		Mo^{99}	$4.62x10^{11}$	± 3.9
		Ru^{103}	-	
		Ru^{106}	-	
		I^{131}	$1.09x10^{12}$	

*Units = Atoms

(Continued)

TABLE 3.10 (CONTINUED) NRDL SEDAN RADIOCHEMICAL RESULTS

Units: Equivalent Fissions/Gm

Station No.	Screen Retained On	Isotope	Value	Standard Deviation
	Tyler Mesh			%
14	Pan	Te^{131}	-	
		Te^{132}	$8.12x10^{11}$	± 4.2
		Cs^{136}	$5.85x10^{11}$	± 14.8
		Cs^{137}	$1.16x10^{12}$	± 2.9
		Ba^{140}	$8.79x10^{11}$	
		Ce^{141}	$<5.62x10^{11}$	
		Ce^{144}	$4.94x10^{11}$	± 2.6
		W^{185}	$3.64x10^{12}$*	
19	7	Sr^{89}	-	
		Sr^{90}	-	
		Y^{91}	$1.66x10^{12}$	
		Zr^{95}	$1.23x10^{12}$	
		Mo^{99}	$1.15x10^{12}$	
		Ru^{103}	-	
		Ru^{106}	-	
		I^{131}	$1.54x10^{12}$	± 5.0
		Te^{131}	-	
		Te^{132}	$1.62x10^{12}$	± 6.2
		Cs^{136}	$1.69x10^{12}$	± 7.7
		Cs^{137}	$2.38x10^{11}$	
		Ba^{140}	$8.36x10^{11}$	
		Ce^{141}	$1.21x10^{12}$	± 26.0
		Ce^{144}	$1.32x10^{12}$	± 4.7
		W^{185}	$2.88x10^{12}$*	
19	12	Sr^{89}	$7.77x10^{10}$	
		Sr^{90}	$2.41x10^{11}$	
		Y^{91}	$2.76x10^{11}$	
		Zr^{95}	$3.48x10^{11}$	
19	24	Sr^{89}	$2.02x10^{11}$	
		Sr^{90}	$3.19x10^{11}$	
		Y^{91}	$6.32x10^{11}$	
		Zr^{95}	$1.07x10^{12}$	

*Units = Atoms

(Continued)

TABLE 3.10 (CONTINUED) NRDL SEDAN RADIOCHEMICAL RESULTS

Units: Equivalent Fissions/Gm

Station No.	Screen Retained On	Isotope	Values	Standard Deviation
	Tyler Mesh			%
19	80	Sr^{89}	$1.15x10^{11}$	± 3.3
		Sr^{90}	$2.11x10^{11}$	± 4.5
		Y^{91}	$6.63x10^{11}$	
		Zr^{95}	$4.69x10^{11}$	± 3.5
		Mo^{99}	$4.81x10^{11}$	
		Ru^{103}	-	
		Ru^{106}	$2.91x10^{11}$	± 4.2
		I^{131}	$3.27x10^{11}$	± 21.0
		Te^{131}	-	
		Te^{132}	$2.23x10^{11}$	± 2.6
		Cs^{136}	$5.28x10^{11}$	± 8.1
		Cs^{137}	$1.48x10^{11}$	
		Ba^{140}	$3.43x10^{11}$	± 2.4
		Ce^{141}	$2.95x10^{11}$	± 6.7
		Ce^{144}	$5.20x10^{11}$	± 5.6
		W^{185}	$1.54x10^{12}$*	± 4.2
19	170	Sr^{89}	$2.32x10^{11}$	
		Sr^{90}	$3.81x10^{11}$	
		Y^{91}	$3.10x10^{11}$	
		Zr^{95}	$4.00x10^{11}$	
19	325	Sr^{89}	$4.18x10^{11}$	
		Sr^{90}	$5.60x10^{11}$	
		Y^{91}	$5.19x10^{11}$	
		Zr^{95}	$5.31x10^{11}$	
19	Pan	Sr^{89}	$1.25x10^{12}$	
			$6.92x10^{11}$	
		Sr^{90}	$1.64x10^{12}$	
			$1.09x10^{12}$	
		Y^{91}	$8.42x10^{11}$	
			$1.02x10^{12}$	± 2.5
		Zr^{95}	$4.99x10^{11}$	
			$3.06x10^{11}$	± 3.3

*Units = Atoms

(Continued)

TABLE 3.10 (CONTINUED) NRDL SEDAN RADIOCHEMICAL RESULTS

Units: Equivalent Fissions/Gm

Station No.	Screen Retained On	Isotope	Value	Standard Deviation
	Tyler Mesh			%
19	Pan	Mo^{99}	3.74×10^{11}	± 5.2
		Ru^{103}	-	
		Ru^{106}	9.48×10^{11}	± 3.3
		I^{131}	7.64×10^{11}	± 6.6
		Te^{131}	-	
		Te^{132}	7.78×10^{11}	± 6.3
		Cs^{136}	4.97×10^{10}	± 5.7
		Cs^{137}	7.25×10^{11}	± 5.4
		Ba^{140}	7.62×10^{11}	
		Ce^{141}	4.27×10^{11}	± 6.0
		Ce^{144}	3.50×10^{11}	± 4.2
		W^{185}	3.40×10^{12}*	± 2.9
20	7, 12, 24	Sr^{89}	1.82×10^{11}	
		Sr^{90}	2.80×10^{11}	
		Y^{91}	6.17×10^{11}	
		Zr^{95}	1.17×10^{12}	
20	80	Sr^{89}	1.79×10^{11}	
		Sr^{90}	3.38×10^{11}	
		Y^{91}	3.72×10^{11}	
		Zr^{95}	5.66×10^{11}	
20	170	Sr^{89}	2.04×10^{11}	
		Sr^{90}	2.83×10^{11}	
		Y^{91}	2.56×10^{11}	
		Zr^{95}	3.48×10^{11}	
20	325	Sr^{89}	3.18×10^{11}	
		Sr^{90}	4.78×10^{11}	
		Y^{91}	4.75×10^{11}	
		Zr^{95}	4.29×10^{11}	
20	Pan	Sr^{89}	1.07×10^{11}	
		Sr^{90}	1.54×10^{11}	
		Y^{91}	3.85×10^{11}	
		Zr^{95}	3.58×10^{11}	

*Units = Atoms

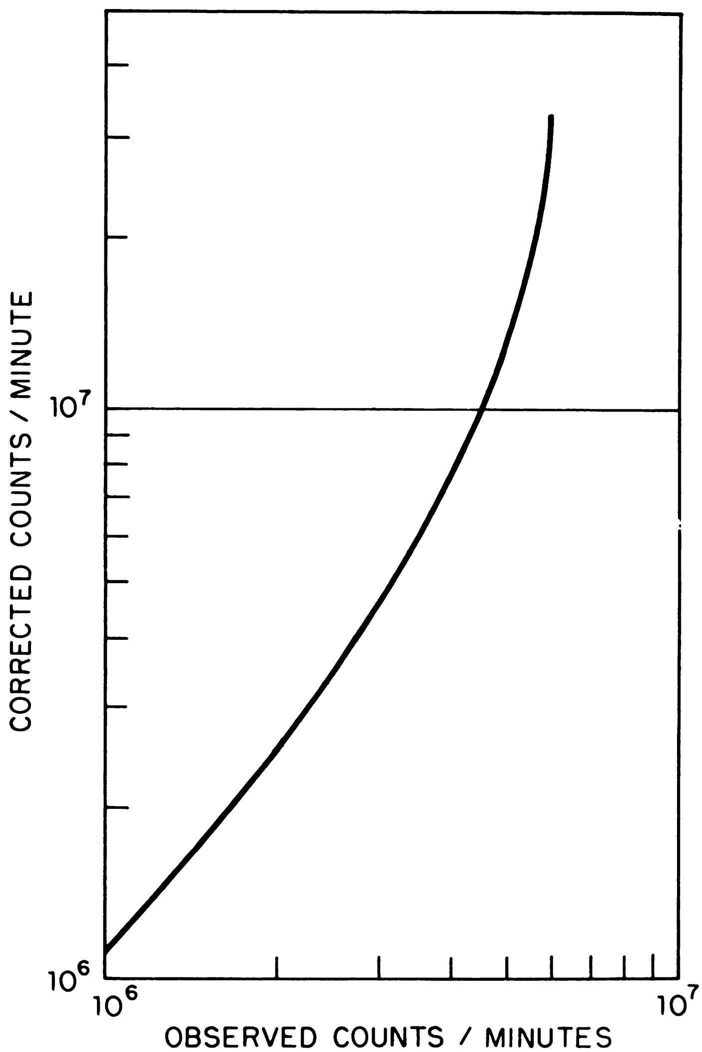

Figure 3.1 Coincidence correction for gamma scintillation counter.

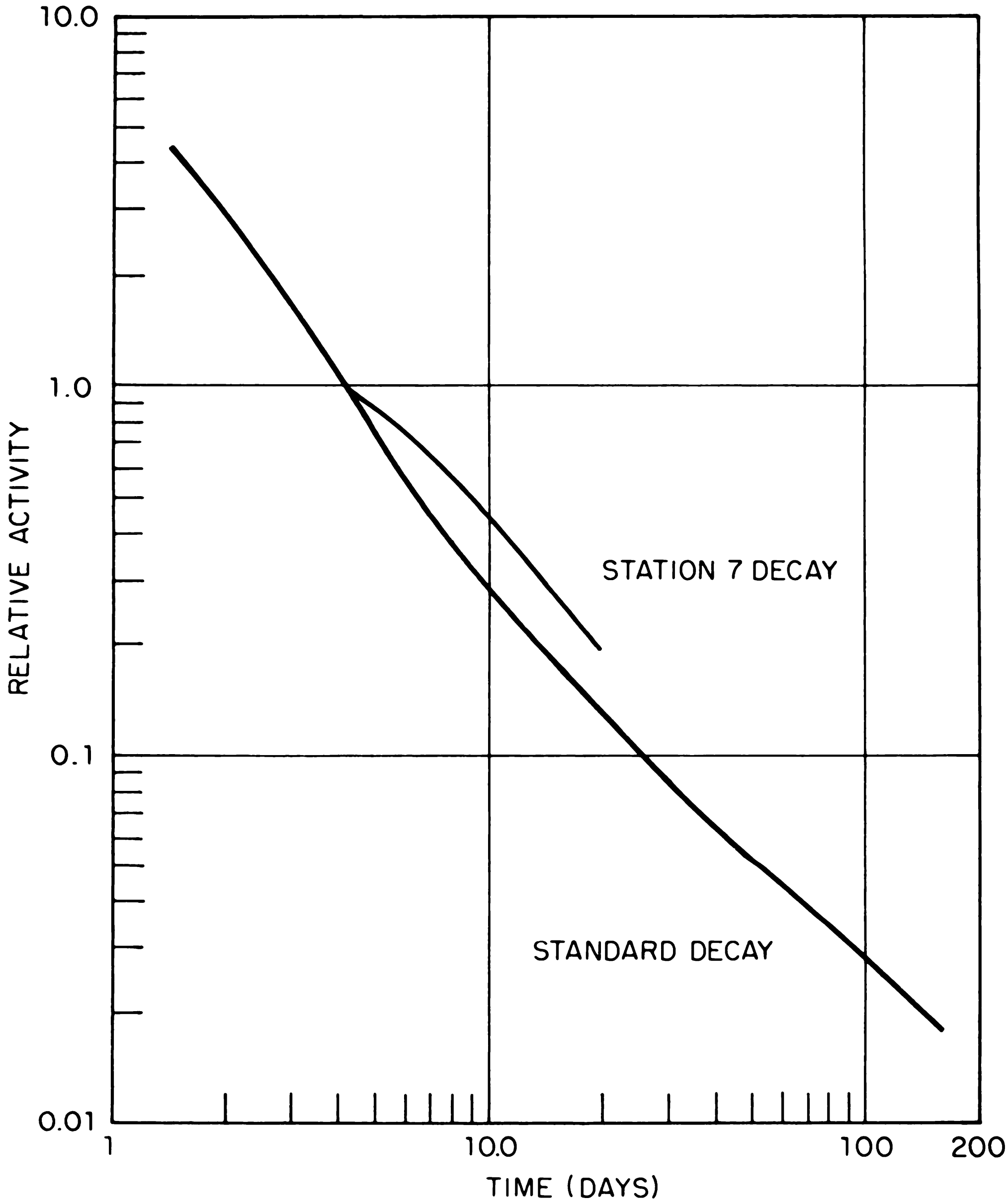

Figure 3.2 Standard decay curve for scintillation counter and Station 7 decay.

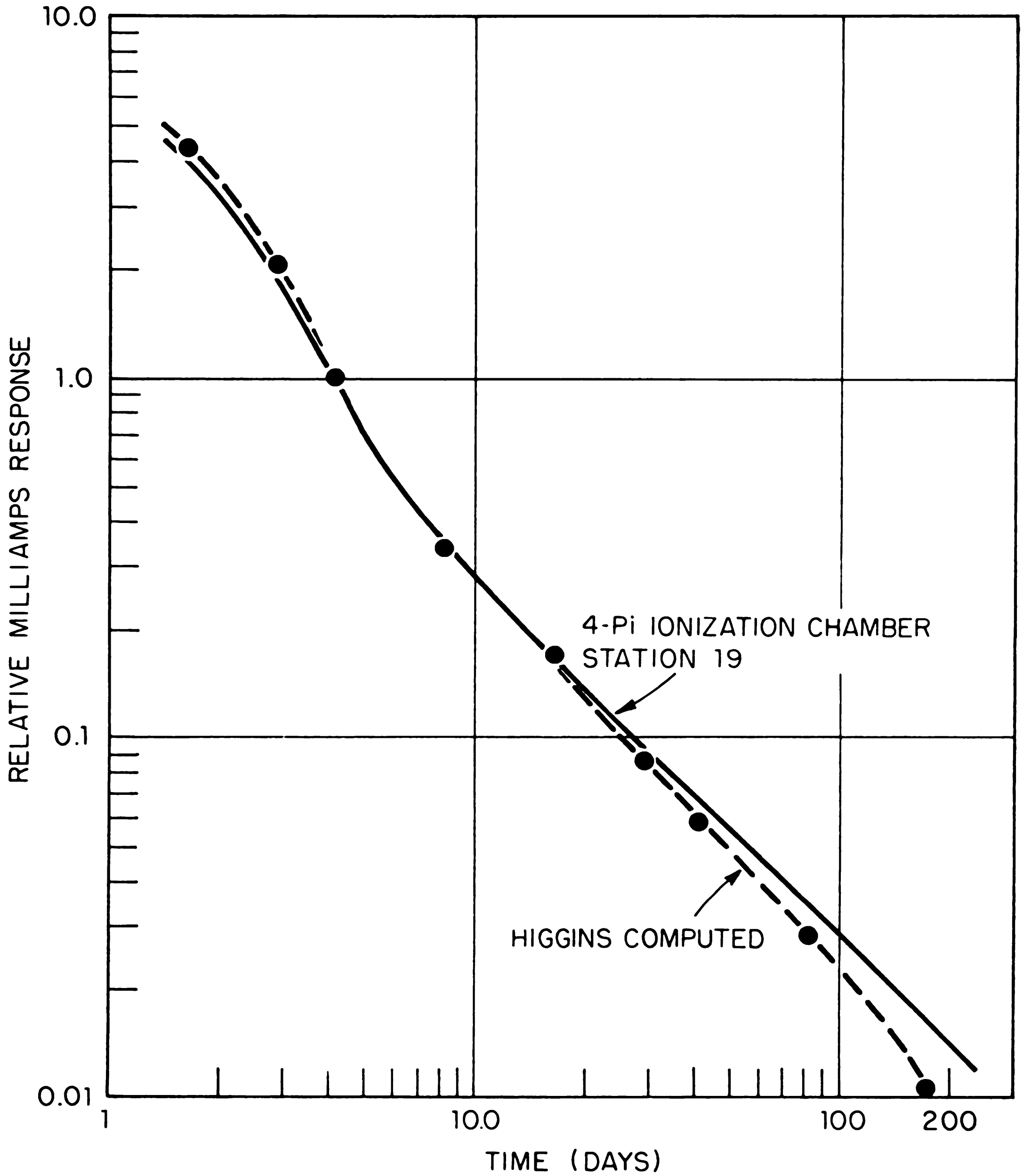

Figure 3.3 Standard 4-pi ionization chamber decay curve and computed decay curve.

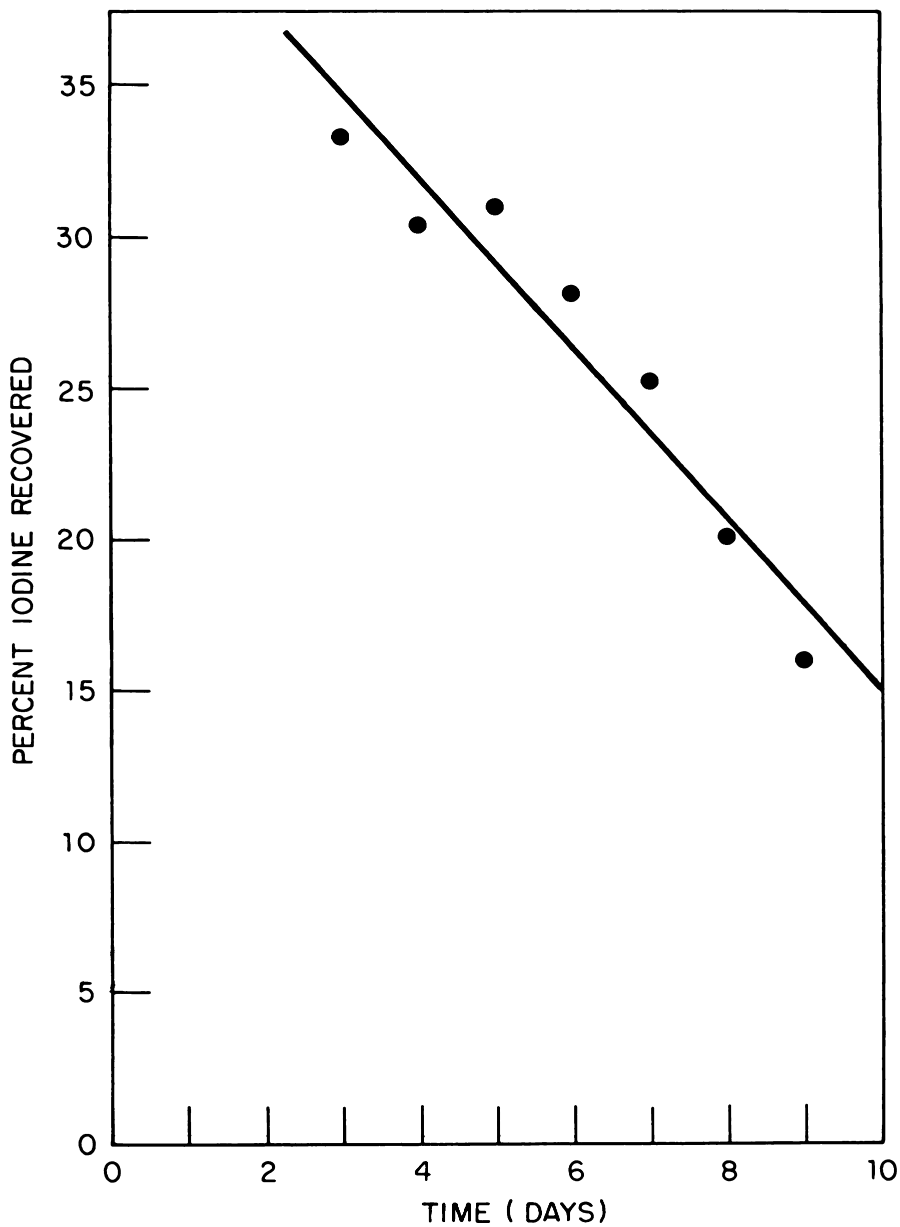

Figure 3.4 Loss of iodine from particulate debris by air exposure.

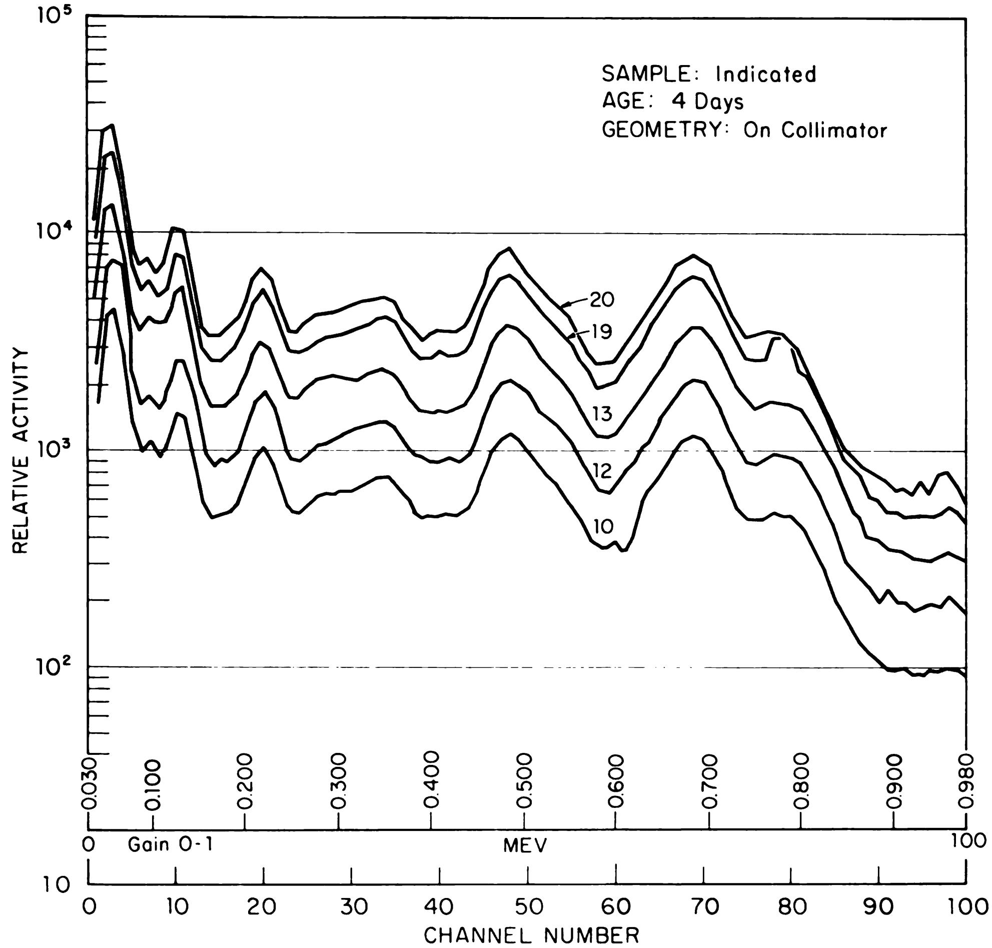

Figure 3.7 Pulse height distribution of activity from different locations.

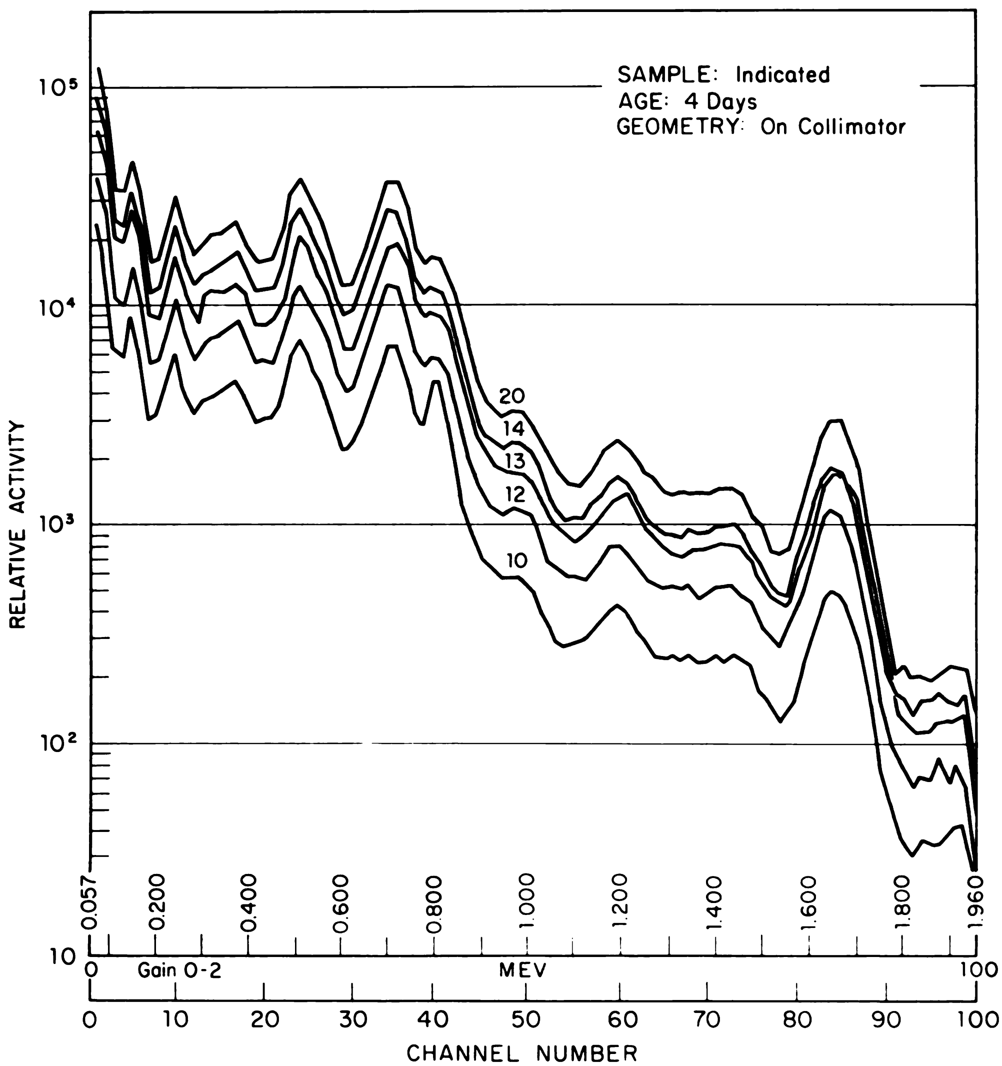

Figure 3.8 Pulse height distributions of activity from different locations.

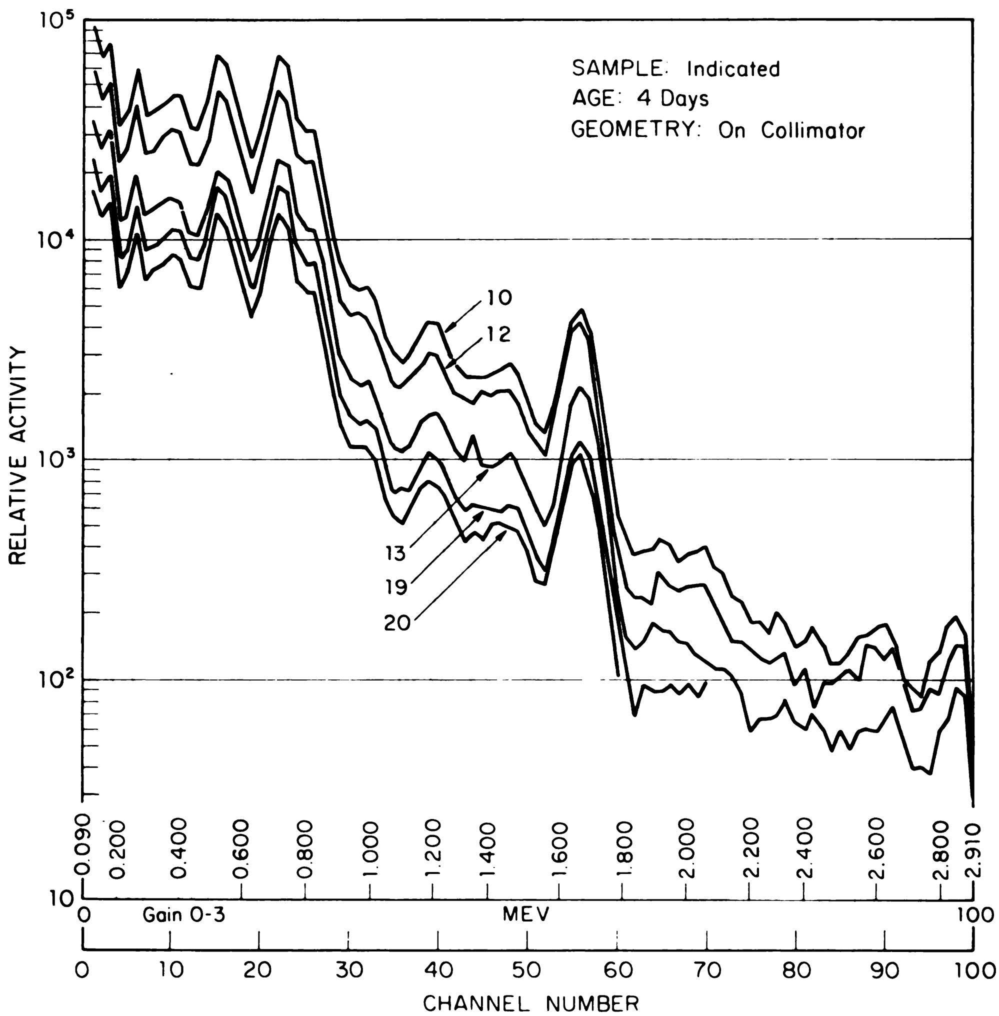

Figure 3.9 Pulse height distributions of activity from different locations.

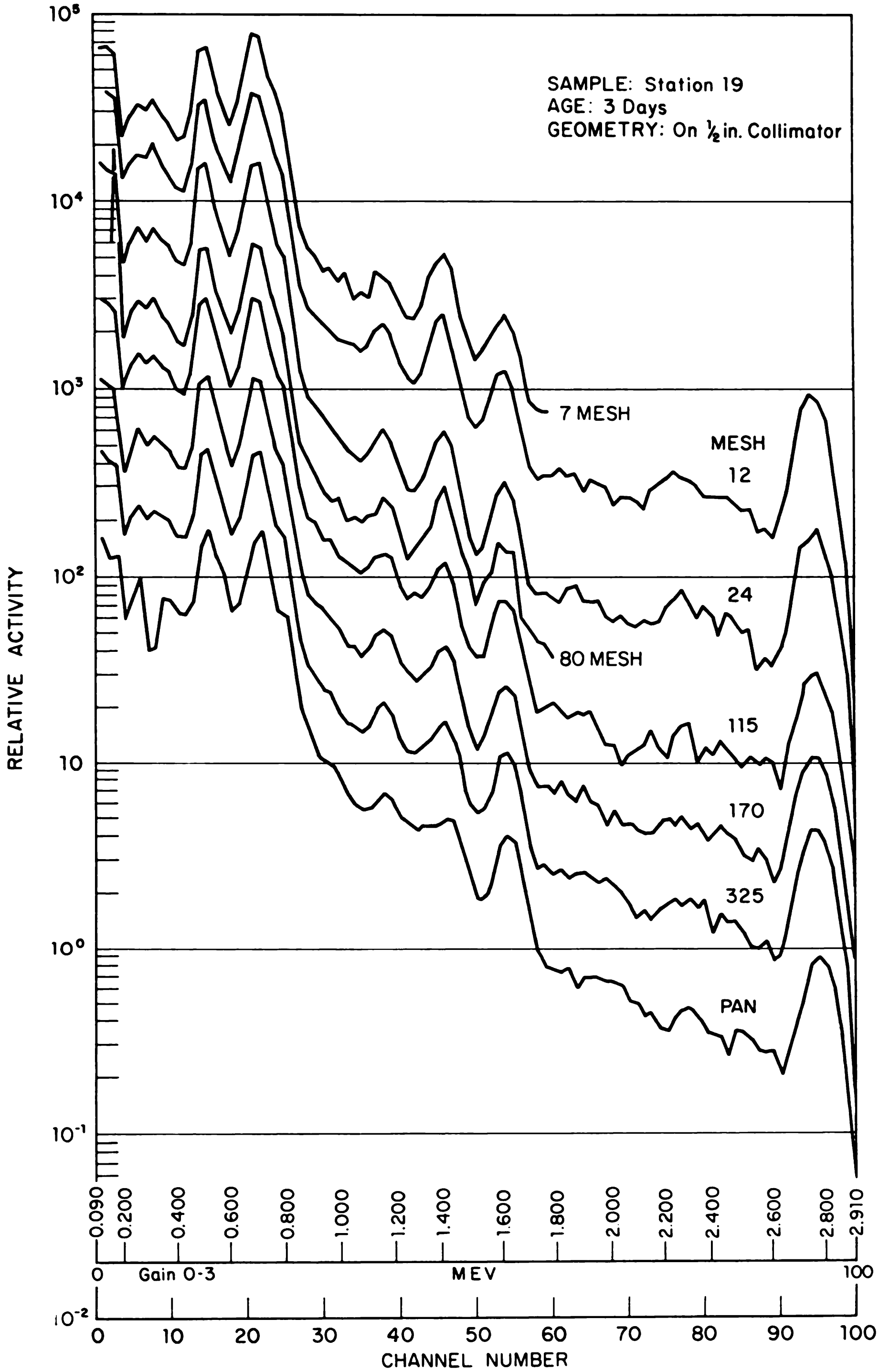

Figure 3.10 Pulse height distributions of sieved fractions.

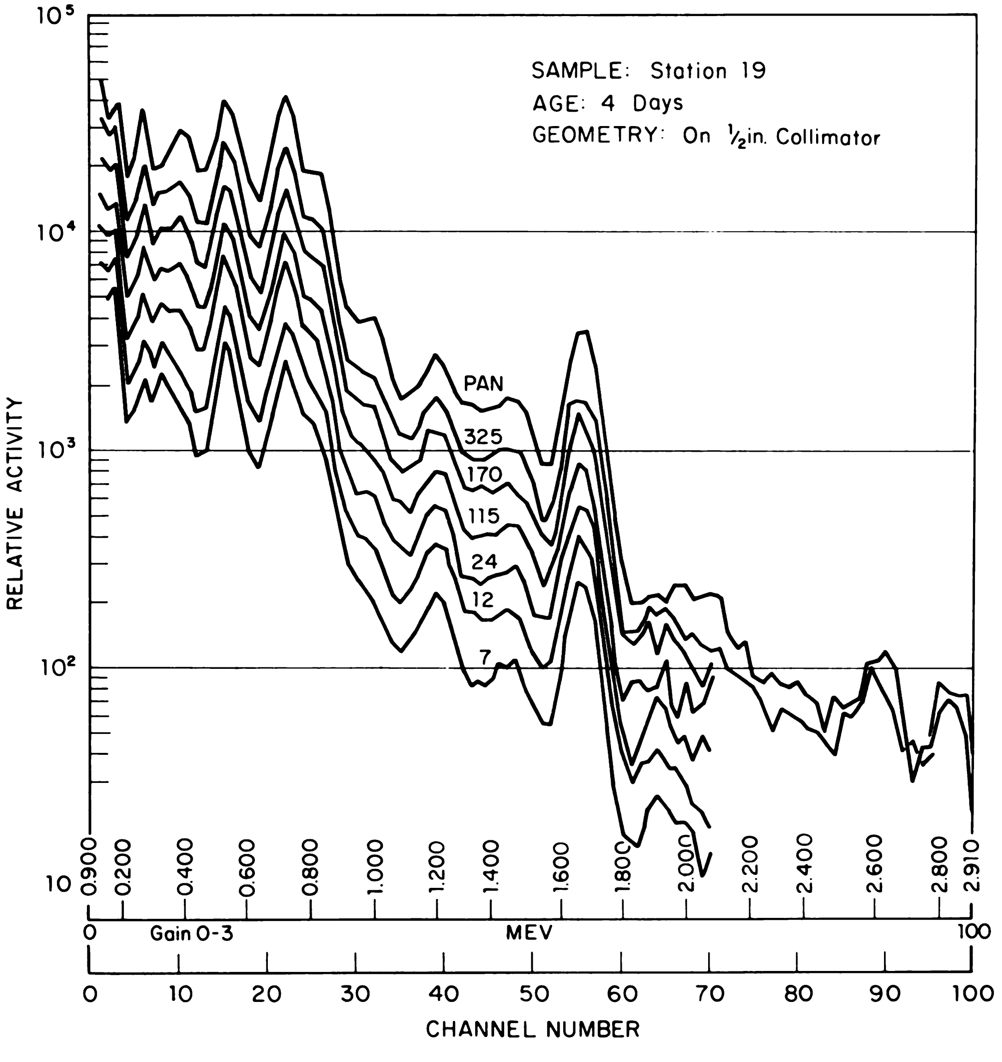

Figure 3.11 Pulse height distributions of sieved fractions.

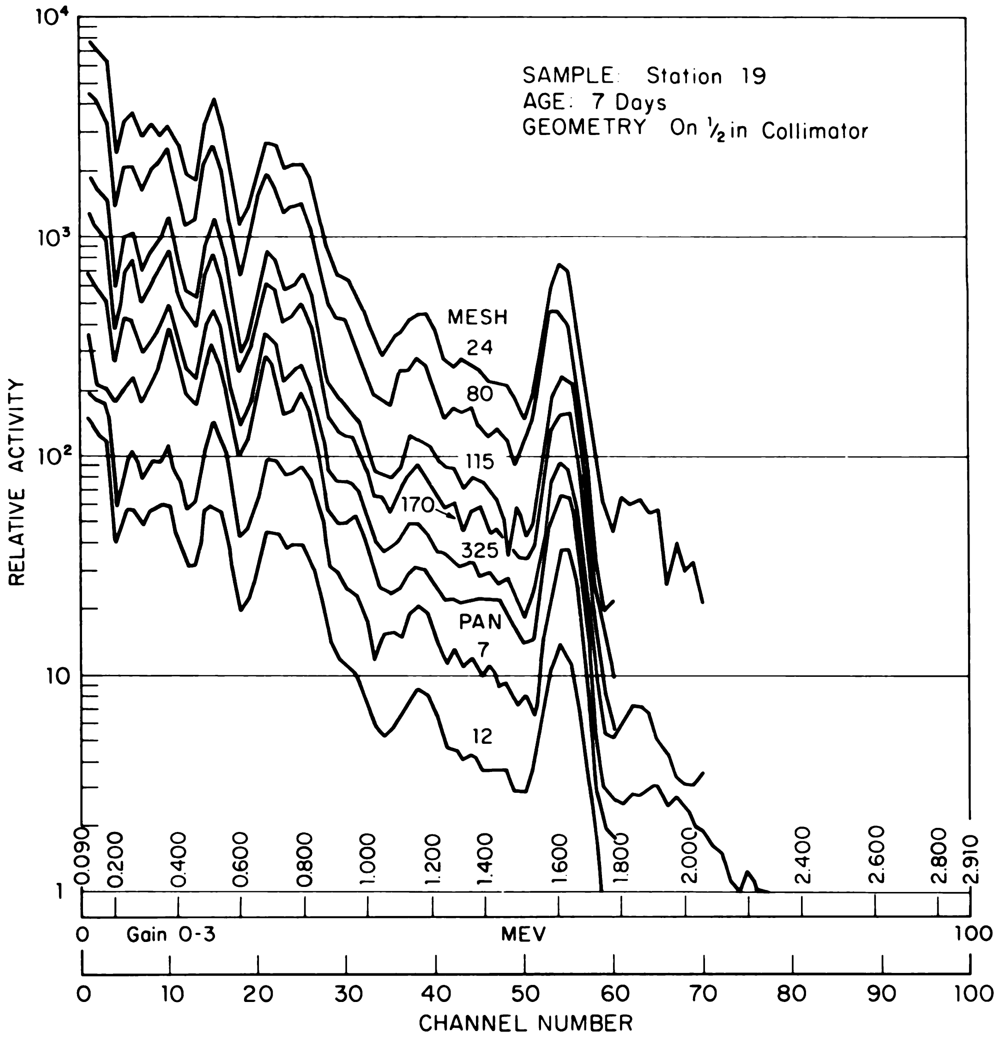

Figure 3.12 Pulse height distributions of sieved fractions.

CHAPTER 4

CONCLUSIONS

1. Sufficient data were obtained to satisfy the objectives of Project 62.90.

2. Gamma decay measurements showed no evidence of radionuclide fractionation in debris from different locations, nor among different particle size fractions. Decay measurements showed excellent agreement with a computed decay rate.

3. Measurements of mass and activity distributions indicate that the radionuclides are associated with the volume of the particles rather than with their surface area. However the wet sieving technique may have partially removed surface activity.

4. Specific activity of the debris generally increased with increasing distance downwind from ground zero which seems to indicate a relationship between specific activity and surface area.

5. Airborne iodine fission products were found in the contaminated field downwind from ground zero.

6. It was found that iodine fission products volatilize and are released from particulate fallout.

7. Pulse height distribution were similar for debris from different locations, and different sized fractions, again indicating no significant fractionation of gamma emitting radionuclides.

REFERENCES

1. P. D. LaRiviere; "Response of a Low-Geometry Scintillation Counter to Fission and Other Products"; USNRDL-TR-303, February 1959; U. S. Naval Radiological Defense Laboratory, San Francisco, California.

2. C. F. Miller; "Response Curves for USNRDL 4-pi Ionization Chamber"; USNRDL-TR-155, May 1957; U. S. Naval Radiological Defense Laboratory, San Francisco, California.

3. C. S. Cook and others; "Neutron Induced Activities in Soil Elements", Project 2.2, Operation Plumbbob, WT-1411, July 1959; U. S. Naval Radiological Defense Laboratory.

4. W. B. Lane, J. D. Sartor; "Stoneman II Test of Reclamation Performance, Vol. 1. The Production, Dispersal and Measurement of Synthetic Fallout Material", USNRDL-TR-334, 6 June 1960; U. S. Naval Radiological Defense Laboratory, San Francisco, California.

5. C. F. Miller and P. Loeb; "Ionization Rates and Photon Pulse Decay of Fission Products From the Slow-Neutron Fission of U^{235}"; USNRDL-TR-247, 4 August 1958; U. S. Naval Radiological Defense Laboratory, San Francisco, California.

6. R. C. Bolles and N. E. Ballou; "Calculated Activities and Abundances of U^{235} Fission Products"; USNRDL-TR-456, 30 August 1956; U. S. Naval Radiological Defense Laboratory, San Francisco, California.

7. L. Wish and E. C. Freiling; "Quantitative Radio-chemical Carrier Free Procedures"; USNRDL-TR-464, 8 July 1960; U. S. Naval Radiological Defense Laboratory, San Francisco, California.

8. E. C. Freiling; "Fractionation I, High Yield Surface Burst Correlations"; USNRDL-TR-385, October 1959; U. S. Naval Radiological Defense Laboratory, San Francisco, California.